Ministry of Education and Science of the Russian Federation
Federal Independent Educational Institution
«NATIONAL RESEARCH TOMSK POLYTECHNIC UNIVERSITY»

Research School of Chemistry & Applied Biomedical Sciences
Program/specialty 12.04.04 «Biotechnical systems and technologies»

MASTER'S THESIS

Topic of the work
Разработка программного комплекса для оценки и реабилитации двигательных расстройств при поражении центральной нервной системы **Development of a software package for the assessment and rehabilitation of motor disorders in lesions of the central nervous system**

UDC: 004.415.2:004.946:616.831

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Tomsk – 2020

Planned program learning outcomes

Код результата	Результат обучения (выпускник должен быть готов)	Требования ФГОС, критериев и/или заинтересованных сторон
Профессиональные компетенции		
P1	Применять глубокие специальные естественнонаучные, математические, социально-экономические и профессиональные знания в инновационной инженерной деятельности при разработке, производстве, исследовании, эксплуатации, обслуживании и ремонте современной биомедицинской и экологической техники	Требования ФГОС (ОК-2, ОПК-2), Критерий 5 АИОР (п. 5.2.1), согласованный с требованиями международных стандартов *EUR-ACE* и *FEANI*
P2	Ставить и решать инновационные задачи инженерного анализа и синтеза с использованием специальных знаний, современных аналитических методов и моделей	Требования ФГОС (ОПК-1, 3; ПК- 1 – 4), Критерий 5 АИОР (п. 5.2.2), согласованный с требованиями международных стандартов EUR-ACE и FEANI
P3	Выбирать и использовать необходимое оборудование, инструменты и технологии для ведения инновационной практической инженерной деятельности с учетом экономических, экологических, социальных и иных ограничений	Требования ФГОС (ОК-9, ПК-10, 14, 18). Критерий 5 АИОР (пп. 5.2.3, 5.2.5), согласованный с требованиями международных стандартов EUR-ACE и FEANI
P4	Выполнять комплексные инженерные проекты по разработке высокоэффективной биомедицинской и экологической техники конкурентоспособной на мировом рынке	Требования ФГОС (ОК-2, 3; ПК-5 – 11, 14), Критерий 5 АИОР (пп. 5.2.3, 5.2.5), согласованный с требованиями международных стандартов *EUR-ACE* и *FEANI*
P5	Проводить комплексные инженерные исследования, включая поиск необходимой информации, эксперимент, анализ и интерпретацию данных с применением глубоких специальных знаний и современных методов для достижения требуемых результатов в сложных и неопределенных условиях	Требования ФГОС (ОК-2, 3; ОПК-5, ПК-1 – 4). Критерий 5 АИОР (пп. 5.2.2, 5.2.4), согласованный с требованиями международных стандартов *EUR-ACE* и *FEANI*
P6	Внедрять, эксплуатировать и обслуживать современное высокотехнологичное оборудование в предметной сфере биотехнических систем и технологий, обеспечивать его высокую эффективность, соблюдать правила охраны здоровья и безопасности труда, выполнять требования по защите окружающей среды	Требования ФГОС (ОПК-1, 2), Критерий 5 АИОР (пп. 5.2.5, 5.2.6), согласованный с требованиями международных стандартов *EUR-ACE* и *FEANI*
Универсальные компетенции		
P7	Использовать глубокие знания в области проектного менеджмента для ведения инновационной инженерной деятельности с учетом юридических аспектов защиты интеллектуальной собственности	Требования ФГОС (ОПК-2; ПК-14, 15). Критерий 5 АИОР (п. 5.3.1), согласованный с требованиями международных стандартов *EUR-ACE* и *FEANI*
P8	Владеть иностранным языком на уровне, позволяющем активно осуществлять коммуникации в профессиональной среде и в обществе, разрабатывать документацию, презентовать и защищать результаты инновационной инженерной деятельности	Требования ФГОС (ОК-1), Критерий 5 АИОР (п. 5.3.2), согласованный с требованиями международных стандартов *EUR-ACE* и *FEANI*
P9	Эффективно работать индивидуально и в качестве члена и руководителя команды, состоящей из специалистов различных направлений и квалификаций, с делением ответственности и полномочий при решении инновационных инженерных задач	Требования ФГОС (ОК-3, ОПК-3; ПК-3, 12, 13), Критерий 5 АИОР (п. 5.3.3), согласованный с требованиями международных стандартов *EUR-ACE* и *FEANI*
P10	Демонстрировать личную ответственность, приверженность и готовность следовать профессиональной этике и нормам ведения инновационной инженерной деятельности	Критерий 5 АИОР (п. 5.3.4), согласованный с требованиями международных стандартов *EUR-ACE* и *FEANI*
P11	Демонстрировать глубокие знание правовых социальных, экологических и культурных аспектов инновационной инженерной деятельности, компетентность в вопросах охраны здоровья и безопасности жизнедеятельности	Критерий 5 АИОР (п. 5.3.5), согласованный с требованиями международных стандартов *EUR-ACE* и *FEANI*
P12	Самостоятельно учиться и непрерывно повышать квалификацию в течение всего периода профессиональной деятельности	Требования ФГОС (ОК-2, 4; ОПК-4), Критерий 5 АИОР (п.5.3.6), согласованный с требованиями международных стандартов *EUR-ACE* и *FEANI*

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APPROVED BY
Head of the Program
_____ _____ F.A.Gubarev
(Signature) (Date)

ASSIGNMENT
for the Master's Thesis completion

In the form:

Master's Thesis

For a student:

Group	**Full Name**
9DM8I	Skopchenko Evgeny Maksimovich

Topic of the work:

Разработка программного комплекса для оценки и реабилитации двигательных расстройств при поражении центральной нервной системы **Development of a software package for the assessment and rehabilitation of motor disorders in lesions of the central nervous system**	
Approved by the order of the Head (date, number)	

Deadline for completion of the Master's Thesis:	

TERMS OF REFERENCE:

Initial data for work: *(the name of the object of research or design; performance or load; mode of operation (continuous, periodic, cyclic, etc.); type of raw material or material of the product; requirements for the product, product or process; special requirements to the features of the operation of the object or product in terms of operational safety, environmental impact, energy costs; economic analysis, etc.).*	The object of the research: development of a software package for the assessment and rehabilitation of motor disorders in lesions of the central nervous system Subject matter of the research: central nervous system disorders The results of this study can be used to rehabilitate patients with impaired motor functions of the upper and lower extremities, up to the full or partial restoration of fine motor skills and large motor motility
List of the issues to be investigated, designed and developed *(analytical review of literary sources in order to elucidate the achievements of world science and technology in the field under consideration, the formulation of the problem of research, design, construction, the content of the procedure of the research, design, construction, discussion of the performed work results, the name of additional sections to be developed; work conclusion).*	• Writing a review of the literature and analysis on the topic; • Research of existing developments in this area, planning the creation of software • Completion of equipment and software for creating a software package • Creation of a software package for the rehabilitation of motor disorders in augmented reality; • Research of results and their interpretation; • Assessment of the possibility of further development of this path

	• Feasibility study; • Industrial and environmental safety.
List of graphic material *(with an exact indication of mandatory drawings)*	
Advisors on the sections of the Master's Thesis	
Chapter	**Advisor**
Section «Financial Management, Resource Efficiency and Resource Saving»	Associate professor, Menshikova Ekaterina Valerievna
Section «Social Responsibility»	Associate Professor, Mikhail Vladimirovich Gorbenko

Date of issuance of the assignment for Master's Thesis completion according to a line schedule	

The task was issued by the Scientific Supervisor and Technical Advisor:

Position	Full Name	Academic degree, rank	Signature	Date
Associate Professor, SSMU	Tolmachev Ivan Vladislavovich	Candidate of Technical Sciences		
Associate Professor, TPU	Gubarev Fedor Alexandrovich	Candidate of Physical and Mathematical Sciences		

The assignment was accepted for execution by the student:

Group	Full Name	Signature	Date
9DM8I	Skopchenko Evgeny Maksimovich		

ASSIGNMENT FOR SECTION
«FINANCIAL MANAGEMENT, RESOURCE EFFICIENCY AND RESOURCE SAVING»

To the student:

Group	Full name
9DM8I	Skopchenko Evgeny Maksimovich

School	RSCABS	**Division**	
Degree	Master	**Educational Program**	12.04.04 Biotechnical systems and technologies

Input data to the section «Financial management, resource efficiency and resource saving»:	
1. *Resource cost of scientific and technical research (STR): material and technical, energetic, financial and human*	– Salary costs – 375012 rubles – STR budget – 773725 rubles.
2. *Expenditure rates and expenditure standards for resources*	– Electricity costs – 3487 rubles.
3. *Current tax system, tax rates, charges rates, discounting rates and interest rates*	– Labor tax – 14,71 %; – Overhead costs – 13,79%;
The list of subjects to study, design and develop:	
1. *Assessment of commercial and innovative potential of STR*	– comparative analysis with other researches in this field;
2. *Development of charter for scientific-research project*	– SWOT-analysis;
3. *Scheduling of STR management process: structure and timeline, budget, risk management*	– calculation of working hours for project; – creation of the time schedule of the project; – calculation of scientific and technical research budget;
4. *Resource efficiency*	– integral indicator of resource efficiency for the developed project.
A list of graphic material *(with list of mandatory blueprints):*	
1. *Competitiveness analysis* 2. *SWOT- analysis* 3. *Gantt chart and budget of scientific research* 4. *Assessment of resource, financial and economic efficiency of STR* 5. *Potential risks*	

Date of issue of the task for the section according to the schedule	3.02.2020

Task issued by adviser:

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TASK FOR SECTION
«SOCIAL RESPONSIBILITY»

For the student:

Group	Full name
9DM8I	Skopchenko Evgeny Maksimovich

School	RSCABS	Department	
Level of ducation	Master's degree	**Program/Specialty**	12.04.04 Biotechnical systems and technologies

Topic of the work

Разработка программного комплекса для оценки и реабилитации двигательных расстройств при поражении центральной нервной системы **Development of a software package for the assessment and rehabilitation of motor disorders in lesions of the central nervous system**	
Initial data to the section «Social responsibility»:	
1. *Characteristics of the object of study (substance, material, device, algorithm, method, working area) and its areas of application*	*Development of a software package for the assessment and rehabilitation of motor disorders in lesions of the central nervous system using video capture.. Video capture can be used to accurately determine the coordinates of the location of the hand and fingers.* *The workplace is located in a laboratory room equipped with a computer, a work desk, laboratory equipment, lamps for lighting the working area.*
The list of issues to be investigated, designed and developed:	
1. Legal and organizational safety issues: *1.1. Special legal norms of labor legislation.* *1.2. Organizational arrangements for the layout of the working area.*	*1.1 Special legal norms of labor legislation.* *1.2 Organizational arrangements for the layout of the working area. These include:* *1.2.1. microclimate of the working room;* *1.2.2. illumination of the working area;* *1.2.3. noise level at the workplace;* *1.2.4. increased level of electromagnetic radiation.* *1.2.5 Arrangements for the layout of the working area.*
2. Industrial safety: *2.1. Analysis of harmful and dangerous factors that can be created by object of study and laboratory during research.*	*2.1 Analysis of harmful and dangerous factors that can be created by object of study and laboratory during research. These include:* *2.1.1 Analysis of identified hazardous factors.* *2.1.2 Electrical safety.*

	2.2 Determination of air exchange in laboratory
3. Ecological safety:	*The facility does not affect the environment. Disposal of equipment.*
4. Safety in emergency situations: *4.1. Analysis of probable emergencies that may occur in the laboratory during research.* *4.2. Justification of measures to prevent emergencies and the development of procedures in case of an emergency.*	*Fire safety*

Date of assignment for the section on a linear schedule	3.02.2020

Assignment was issued by an advisor:

Position	Full name	Degree	Signature	Date
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ABSTRACT

Final qualifying work 70 p., 13 fig., 21 tab., 13 sources., 8 appendices.

Keywords: motor impairment, augmented reality, Leap Motion controller, Epson Moverio BT-300 glasses.

The object of study is motor impairment.

Objective: development of a software package for the assessment and rehabilitation of motor disorders in lesions of the central nervous system.

In the process of the study were carried out: analysis of the literature on this topic, selection and creation of the program.

As a result of the study, a software package was developed for the rehabilitation of motor disorders in augmented reality.

Scope: Neurology (stroke, multiple sclerosis).

Economic efficiency / significance of work: mobility in use.

Definitions, symbols, abbreviations, normative references

The following abbreviations are used with the corresponding decodings:

- PC - personal computer
- AR – augmented reality
- VR – virtual reality
- Soft – Software
- OS - operating system

Normative references:

1. SanPin 2.2.4.548-96 Hygienic requirements for the microclimate of industrial premises.
2. GOST 12.1.030-81 Occupational safety standards system (OSSS). Electrical safety. Protective grounding. Grounding (with Change N1).
3. GOST R 12.1.019-2009 Occupational safety standards system. Electrical safety. General requirements and nomenclature of kinds of protection.
4. FSS 105–03 Determination of categories of rooms, buildings and external installations on explosion and fire hazard.
5. SoR 52.13330.2011 Daylighting and artificial lighting.
6. SanPin 2.2.2 / 2.4.1340-03 Hygienic requirements for personal electronic computers and organization of work.
7. GOST 12.2.032-78 OSSS. Operator's location in a sitting position. General ergonomic requirements.
8. The Labor Code of the Russian Federation dated December 30, 2001 N 197 – TFL.
9. GOST 12.1.005-88 Occupational safety standards system. General sanitary requirements for working zone air.
10. GN 2.1.6.3492-17 Maximum allowable concentrations (MPC) of pollutants in the air of urban and rural settlements.
11. SP 60.13330.2012 Heating, ventilation and air conditioning. Updated edition of SNiP 41-01-2003.

12. On the issue of regulation of air exchange by the CO2 content in the external and internal air [Electronic resource] // URL: https://www.abok.ru/for_spec/articles.php?nid=4046

13. Calculation of required air exchange [Electronic resource] // URL: https://portal.tpu.ru/SHARED/a/ANL/work2/Tab1/Tab3/%D0%97%D0%B0%D0%B4%D0%B0%D0%BD%D0%B8%D0%B5%20%D0%9F%D0%BE%D1%82%D1%80%D0%B5%D0%B1%D0%BD%D1%8B%D0%B9%20%D0%B2%D0%BE%D0%B7%D0%B4%D1%83%D1%85%D0%BE%D0%BE%D0%B1%D0%BC%D0%B5.pdf

Content

Introduction

Currently, augmented reality technologies have reached a high level of development even before the introduction of AR in all spheres of life. However, the real potential of augmented reality is tremendous. We must admit that AR is seen more as a marketing "toy", as yet another marketing ploy that replaced the advertised 3D glasses in glossy magazines. However, the real potential of augmented reality is huge. AR is able to completely transform our entire world, making it more convenient, safe and interactive. AR is a kind of "bridge" between the real and virtual worlds. This is its main advantage over fully virtual reality (VR). AR in its essence requires contact with reality. It does not replace, but complement it. This eliminates the possible psychological dangers of using this technology in education, starting from a very young age. [1]

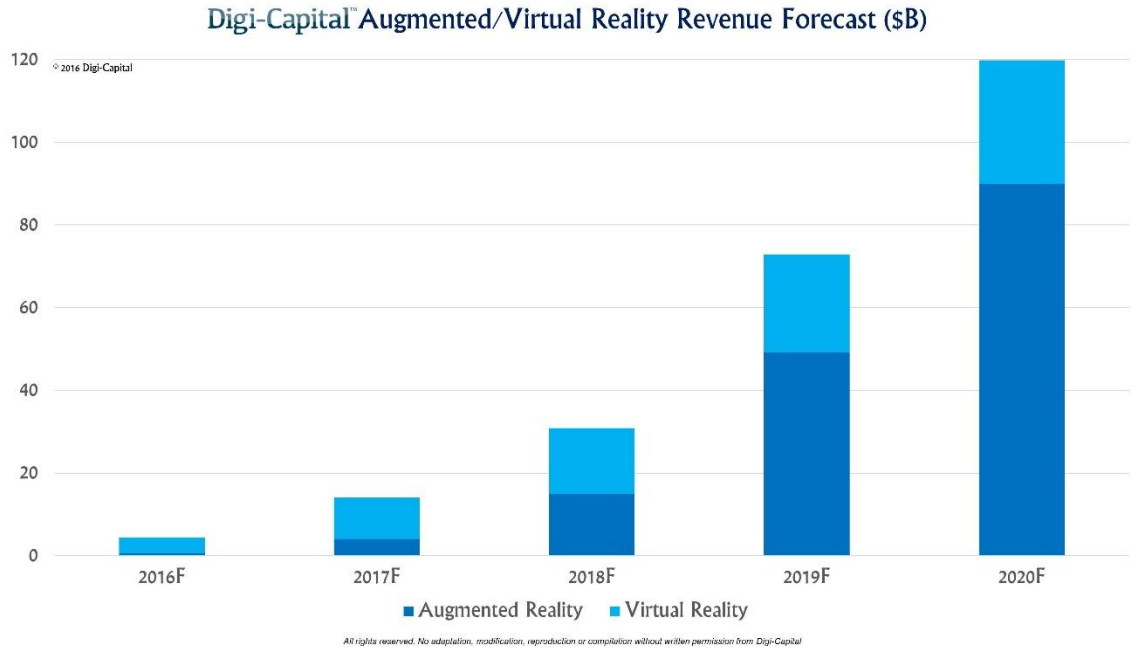

Figure 1. Augmented / virtual reality usage statistics.

Currently, augmented reality is widely used in various fields, such as the media, medicine during operations and rehabilitation of patients after a stroke, military technologies, for example, augmented reality is built into the pilot's helmet so that he can see the world around him, supplemented with necessary information in the AR glasses for the convenience and ease of use of the aircraft, without being distracted by individual devices on the panel. [3]

The basic and comprehensive idea is to define the tasks and their purpose, and then improve them using augmented reality. Some of the presented products have already taken their place in the market and are used in hospitals. Others are in their earlier stages. [1]

Purpose and tasks

Purpose:

Creation of a software package for the rehabilitation of motor disorders in augmented reality.

Tasks:

1. Analysis of modern rehabilitation methods using virtual and augmented reality technologies and preparation of requirements for the software complex.
2. Software prototyping.
3. The implementation of several types of rehabilitation methods based on augmented reality glasses.

1. Literature review

1.1 Augmented Reality.

Augmented reality is a technology of adding, introduction into real life and a three-dimensional field of human perception of virtual information, which is perceived as an element of real life. With quality content, a person erases the line between reality and the artificially created world. Reality is expanding (or supplementing) by introducing virtual information into it. [2].

Thus, in the creation of augmented reality in real time, objects are placed in real time using special software and gadgets, such as:

- Augmented reality glasses (“smart glasses”)
- Map-case.
- Smartphones with AR function and other gadgets.

The world of augmented reality has the following properties:

- Combines virtual and real.
- Interacts in real time.
- Works in 3D.

To create augmented reality, the following devices are used: a processor, display, camera, and position-determining electronics such as an accelerometer, GPS and a compass. A touchscreen smartphone, for example, has the necessary kit so that the owner of the gadget plunges into the world of augmented reality [2,3].

Augmented reality applications work as follows:

- A special mark is used.
- The tag is read by a mobile device or computer.
- A layer of additional information is displayed on the screen.

One of the ways to complement reality is the use of AR-tags (special tags), which are able to encrypt a large amount of information. Augmented reality tag technologies can be divided into:

- marker;
- markerless (based on the coordinates of the user's location).

The marker is usually a surface with a special image. The type of pattern may vary and depends on the image recognition algorithms. There are various types of represented markers, they can have geometric shapes of simple shapes (for example, a circle or a square) and objects in the shape of a rectangular parallelepiped or, for example, people's faces. However, the surface that is used as the output device for a special image is usually static, which means that any movement of an augmented reality object is possible only with special algorithms, which in turn will reduce the accuracy of the location of the object, as well as increase the need for computing power for its location in augmented reality. An alternative to a static image is interactive displays: multi-touch tables, interactive whiteboards, display cases or walls [6,8]

Markerless technologies are based on recognition algorithms, with the help of which a virtual “grid” is superimposed on the surrounding landscape and captured on camera. Software algorithms analyze the “grid”, find reference points (marker), and based on the information about the position of the marker in space, the program can accurately project a virtual object onto it, from which the effect of its physical presence in the surrounding space will be achieved. Using additional graphic filters and high-quality models, a virtual object can become practically real and difficult to distinguish from other elements of the interior or exterior. [6,8]

Conclusion

An analysis of the literature in the field of stroke and after stroke rehabilitation showed that this topic is acutely social. Despite the development of medicine, diagnostic and rehabilitation techniques and technologies, acute cerebrovascular diseases remain diseases with a high percentage of mortality and disability. The early start of rehabilitation increases the chances of restoring motor function, as well as the psycho-emotional state. The introduction of modern information technologies should help doctors and patients to achieve maximum results in the shortest possible time.

The application of virtual and augmented reality technologies can be traced in various fields, such as pilot training, construction and tourism. One of the promising areas is medicine, which has a wide range of applications of these technologies. The ability to teach students using simulators in a virtual environment or three-dimensional visualization of educational material using augmented reality. The use of modern technologies in the rehabilitation of patients with disorders of the musculoskeletal system and fine motor disorders can improve the quality of therapy.

2. Materials and methods

2.1 Types of methods for assessing motor dysfunction.

There are at least 2 ways to evaluate neurological disorders:

- Moving pegs into a container with holes.
- Gorbov-Schulte test.

Implementation of the Gorbov-Schulte test in a virtual environment is much simpler and more practical than “Moving pegs into a container with holes.”

The Gorbov-Schulte estimation method is one of the most popular tests for assessing the speed of attention switching. It is given by psychologists to conclude suitability for professions that require increased concentration and quick response, such as air traffic controllers and train drivers. The red-black Gorbov-Schulte tables are a modified version of the single-color Schulte tables, which are a square divided into 49 cells. Cells are numbers in random order - from 1 to 25 black, and from 1 to 24 red. Colors can be set in various ways. [9]

For example:

1	21	2	6	12	7	7	12	21	23	21	15	19	9
20	5	17	8	22	13	18	2	11	12	14	5	10	19
19	11	12	8	23	3	19	3	25	6	8	13	17	16
17	24	24	10	10	13	5	10	3	9	17	1	18	18
21	2	11	18	6	22	3	6	8	22	7	4	24	14
4	9	25	4	15	9	23	20	4	23	24	20	2	22
15	1	16	14	20	14	16	1	7	15	16	13	5	11

Figure 2. Tables (text color / cell background color).

2.2 Leap Motion Sensor.

The Leap “Motion capture” sensor is a key object in this work. The sensor is used for virtual capture of hands and the creation of their 3D-models on a PC. The sensor uses two monochrome infrared cameras and three infrared emitters. The cameras “scan” the space above the table surface with a frequency of up to 300 frames per second and transfer the received data to a computer, where they are processed by proprietary software. Despite the apparent similarity with Microsoft Kinect, these devices are still different (Kinect uses a color video camera and depth sensors).

Leap Motion should be placed behind the keyboard or in front of it for the convenience of using a motion sensor. As a result, Leap Motion has a rather small size and a wide scanning area, which occupies a small space near the keyboard.

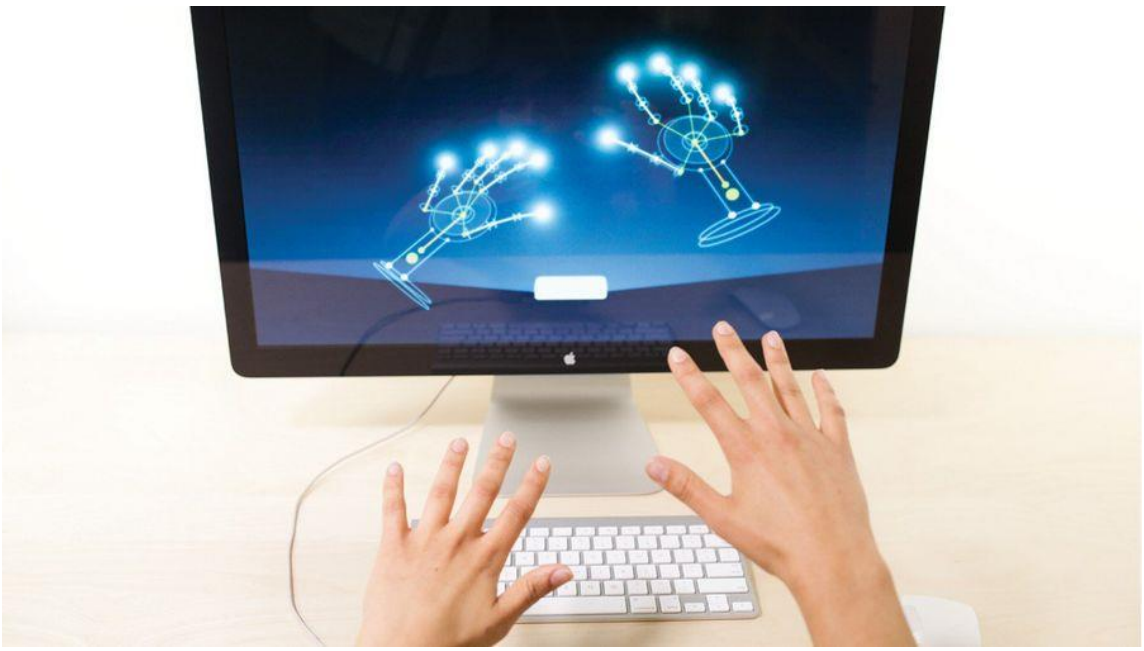

Figure 3. Received data on a PC from a Leap Motion sensor.

The controller works with a computer running Windows, all it takes is download the Airspace utility. Necessary software package is downloaded from the official site. In order for the “Leap Motion” motion sensor to work together with AR glasses or a VR helmet, the developer provides instructions for this. With MacOS, the device also interacts freely, but some hardware problems may occur. In this case, you just need to reconnect the device to the system and wait until it is recognized.

The scanning technology of a moving object is not revolutionary and is actively used in modern computer animation. There are similar products for home user. At the heart of specialized software and conventional webcams or cameras that work in the infrared. Microsoft's Kinect is the most famous and popular similar project. But this controller is positioned mainly as a game. In the recent past, there were attempts to create a controller for controlling a PC however, without the ability to recognize many objects, like Leap Motion. [11]

The setup is automatic. If you need to adjust specific parameters for yourself, you need to the utility settings or use the special Demo from the Airspace Store. There you can see how hand recognition occurs, and adjust sensitivity.

Sensor Features:

• Interface - USB 2.0

• OS - Windows 7/8, Mac OS X 10.7, Linux

• Dimensions, mm - 13 × 13 × 76

• Mass - 45 g

Based on the characteristics and capabilities of the sensor, it is safe to say that the sensor is portable, ultra-convenient to use and the best choice among competitors in the market. [10]

2.3 Augmented reality Epson Moverio BT-300.

Technical characteristics of augmented reality glasses Epson Moverio BT 300:

• time of continuous work - 6 hours;

• light sensor;

• OS - Android, version 5.1;

• wireless connectivity - Bluetooth, WiFi;

• display - Si-OLED;

• built-in memory - 16 GB;

• processor - Intel Atom;

• processor frequency - 1.44;

• sound - Dolby Digital Plus;

• front camera - 5 megapixels;

• additional functions - compass, headset, accelerometer, GPS;

• wireless transmission standard - WiFi Miracast;

• RAM - 2 GB;

• memory card - up to 32 GB;

• perceived image - 40 inches from 2.5 meters - 320 inches from 20 meters;

• contrast characteristics - 100 000: 1;

• screen resolution - 720 HD Ready.

Figure 4. Virtual reality glasses Epson Moverio BT-300.

Si-OLED screen technology is a development of which was applied to Epson Moverio glasses. It enables you to achieve a high level of contrast and provide the colors with the necessary saturation. The technology to make the unused parts of the screen transparent, and the projected image is harmoniously combined with objects of the surrounding world.

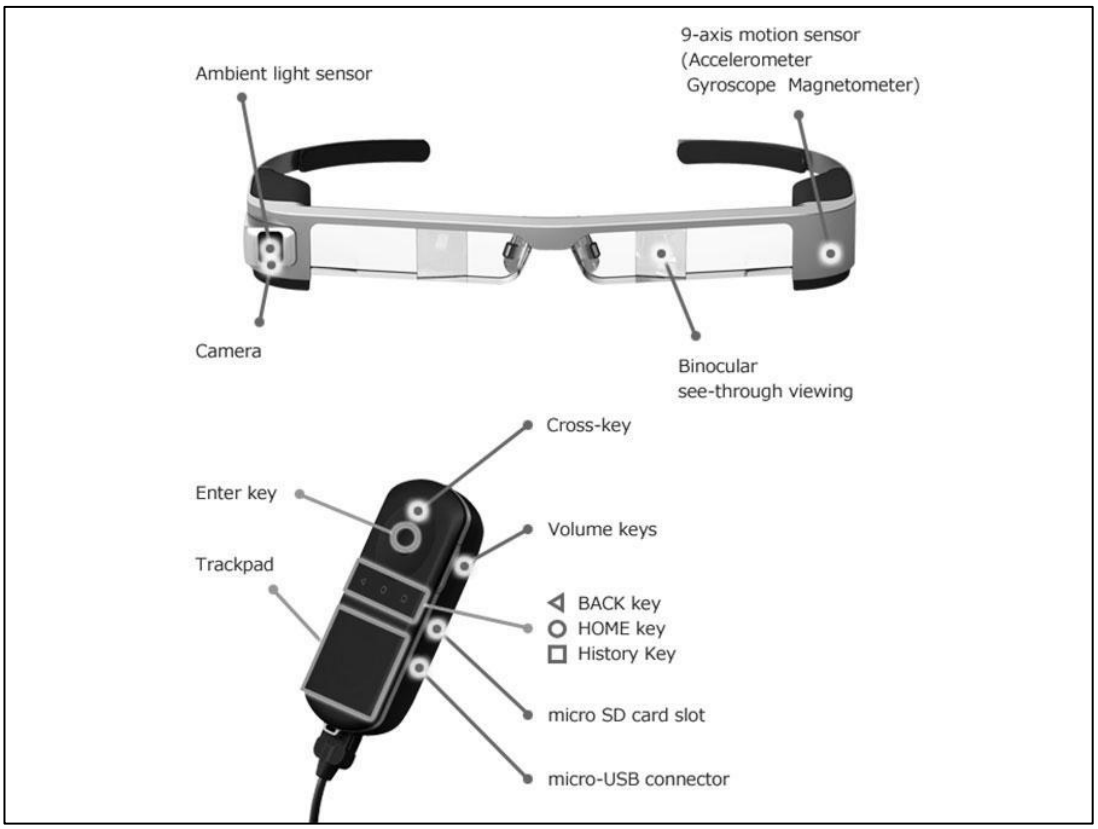

Figure 5. The control panel.

Points are controlled using the remote control (switching on, navigation in the OS interface, settings and other functions). [12]

2.3.1 Augmented reality in medicine.

Example of the use of augmented reality glasses is surgery, where an individual anatomical model of the patient's organs according to the results of computed tomography studies. During the operation, the Epson Moverio BT-200 and specially developed Android-based software superimpose the created anatomical 3D model on the real organ in the surgical field. A doctor who uses glasses can selectively turn off some layers for example, remove the organ model, leaving only the outline and blood vessels. The system monitors not only the position of the organ, but also the position of the surgeon himself, constantly adjusting the picture in accordance with position in space and the deformation of the patient's organ. In addition, solutions with augmented reality showed excellent results in visualization in the field of maxillofacial surgery. [13;4]

2.4 Choice of the environment for the research.

The choice of environment for use in research certainly fell on "Unity" it is free and easy to use. The Unity editor has a simple Drag & Drop interface that is easy to configure, consisting of various windows, so you can debug the application directly in the editor. The engine supports two scripting languages: C# and JavaScript (modification). Previously, there was support for Boo (a dialect of Python), but it was removed in the 5th version. Calculations are performed by the PhysX physics engine from NVIDIA. [5]

The main advantages of Unity are the presence of a visual development environment, cross-platform support and a modular system of components. The disadvantages include the appearance of difficulties when working with multicomponent circuits and difficulties when connecting external libraries.

"Unity" also has a large ready-made database of ready-made scripts, items and other settings with which you can easily necessary scenario for events. Using "Unity", most of the objects and tasks for the application were created. To create

scenes, you only need to select an object and determine its physical parameters [5, 6].

2.5 General requirement.

Application and selection of component devices should be carried out taking into account the following general requirements:

- reliability of devices in operation;
- minimum costs for their operation;
- long service life;
- wide scope;
- minimum cost;
- required performance;

The design of the entire system is determined by mobility universal use by doctors as well as the possibility the application by ordinary citizens.

In this case, you must adhere to the following basic rules:

- Devices should not have a wider measuring range than is really necessary for a specific task.
- The sensitivity of the device must by the needs of control. Sensitive devices are usually very difficult to operate, more expensive and require more qualified service.
- The accuracy of the instrument must be maintained for a long time.
- The application and system should be relatively simple so that their maintenance does not require highly qualified employees. [2]

3. Result.

As a result of the work done, the software package for the rehabilitation of motor disorders in augmented reality was performed using the following materials and methods:

•Development environment	Unity
• Method for assessing motor dysfunction	Gorbova-Schulte
• Motion capture sensor	Leap motion
• Augmented reality glasses	Epson Moverio BT-300

- Epson Moverio BT-300 OS — Android
- PC OS — Windows 10

To start rehabilitation and launch the application:

1. Connect the Leap Motion sensor to the included PC.
2. Cress and enable augmented reality glasses, then launch applications through the remote control.
3. Starting the application.

Based on the outcome of the task, from the beginning of the to the complete restoration of motor functions, we will be able to evaluate the progress of recovery and the progress this process.

3.1 The discussion of the results.

Based on the goal, literature data and hardware and technical equipment, work was carried out to implement additional scenarios in the application for the rehabilitation of patients with varying severity.

3.2 Conclusion.

Despite the development of medicine and diagnosis, stroke remains one of the most common cardiovascular diseases, leading to death and disability. Many rehabilitation techniques have been developed that help and accelerate patient recovery.

Augmented and virtual reality technologies are rapidly developing, which allows them to be used in almost all areas of human activity. The use of AR technology in rehabilitation can help both patients and doctors, accelerating recovery several times.

Combining various technologies, it is possible to achieve even greater results. Development and use of special gloves that can respond to objects in a virtual environment giving tactile feedback. Exoskeletons that help with fine motor activities can help restore motor function.

Technical tools for creating augmented and virtual reality also become more functional with improved technical characteristics. Which contributes to the development of more complex software.

4. Financial management, resource efficiency and resource Saving

4.1 Assessment of the commercial potential and prospects of conducting research from the standpoint of resource efficiency and resource conservation.

4.1.1 Potential consumers of research results.

In this research work, a software package is being developed for the rehabilitation of motor disorders in augmented reality. The results obtained during the work, allow to rehabilitate motor disorders of patients. As a general field of application of the research results, the target consumer is hospitals and special neurological centers where they provide treatment for people with motor impairment disorders. Neurological diseases are common throughout the world and the need to address the field of rehabilitation of motor disorders is also in demand around the globe. Moreover, Russian medicine is interested in introducing modern technologies in all spheres of life and in one of the most important areas - the sphere of medicine. In addition, the development may be of interest to ordinary citizens as a basis for the further development of the application or as a layout. Thus, we can conclude that the main market segment is represented by medical institutions (50%), neurological centers (20%), private clinics (15%), medical universities (10%) and ordinary citizens (5%) in quality base for other programs. This article is a confirmation of the technical solutions described in the release of the qualification work substantiating the economic necessity and expediency of performing scientific and technical research.

The objectives of the section include: determining research results, competitiveness analysis of technical solutions, performing SWOT analysis, calculating the budget of scientific and technical research.

4.1.2 Competitiveness analysis of technical solutions.

To describe the quality of the new development and its prospects in the market, which allows us to decide on the feasibility of investing in a research project, we use an analysis of competitive technical solutions.

An analysis of competitiveness goes between rehabilitation based on:

1. Augmented reality;

2.Virtual reality;

3.Surgery

The analysis of the scorecard is presented in Table 5. The position is evaluated on a five-point scale, where 1 is the weakest position, and 5 is the strongest. The weight of indicators in total should be 1. Analysis of competitive technical solutions is determined by the formula:

$$C = \sum W_i \cdot P_i,$$

Where C is the weighted average of the quality indicator and the prospects of scientific development;

W_i – indicator weight (in fractions of a unit);

P_i – weighted average value of the i-th indicator;

Rehabilitation based on augmented reality was chosen as the main method in this master's dissertation. This method allows recovery to be carried out most efficiently and has greater potential compared to other non-invasive recovery methods (Pf).

Competitors usually apply the methods of Virtual Reality (Pi1) and surgical intervention, which depends on the degree of damage to the neural connections. From which it follows that with small and medium lesions, surgical intervention within the restoration of limb motility is rather a technology of the 20th century (Pi2).

Table 1 - Evaluation card for comparing competitive technical solutions (developments)

Evaluation criteria	**Criterion weight**	**Points**			**Competitiveness** Taking into account weight coefficients		
		P_f	P_{i1}	P_{i2}	C_f	C_{i1}	C_{i2}
1	2	3	4	5	6	7	8
Technical criteria for evaluating resource efficiency							
1. Energy efficiency	0.05	5	5	2	0.25	0.25	0.1
2. Reliability	0.2	4	3	2	0.8	0.6	0.4
3. Safety	0.15	5	5	2	0.75	0.75	0.3
4. Functional capacity	0.1	4	3	3	0.4	0.3	0.3
5. Measurements accuracy	0.2	5	4	2	1	0.8	0.4
Economic criteria for performance evaluation							
1. Development cost	0.07	3	4	2	0.21	0.28	0.14
2. Scientific developments market penetration rate	0.2	4	3	1	0.8	0.6	0.2
3. Methodology perspectives	0.3	4	3	2	1.2	0.9	0.6
Total	**1**	**34**	**30**	**30**	**5.41**	**4.48**	**2.44**

As we see after the analysis of competitiveness, the highest competitiveness scores are observed for our AR (Cif) project and in total are equal to 5.41; while for points VR (Ci1) the total points are equal to 4.48 and rehabilitation through surgery (Ci2) 2.44. AR technology receives a greater amount of points for resource efficiency, security and accuracy of the data received.

4.1.3 SWOT Analysis.

Table 2- SWOT Matrix

Strengths of the research project: C1. Claimed technology efficiency. C2. High functional development power. C3. Lower production cost compared to other technologies. C4. Easy to learn software. C5 Qualified staff.	**Weaknesses of the research project:** S1. Lack of an engineering company capable of building turnkey production S2. Lack of ergonomics S3. Long delivery of components S4. Relatively expensive components
Capabilities: B1. The emergence of additional demand for a new product B2. Reduction of customs duties on materials used in scientific research B3. Increase the cost of competitive development	**Threats:** U1. Lack of demand U2. Developed competition of production technologies U3. Introduction of additional state requirements for product certification U4. Untimely financial support of scientific research by the state.

The second stage is to identify the strengths and weaknesses of the research project to external environmental conditions. This compliance or non-compliance should help to identify the degree to which strategic change is needed.

Table 3 - Interactive matrix of the project

Project Strengths						
		C1	C2	C3	C4	C5
Project Features	B1	+	+	+	–	–
	B2	+	–	+	–	–
	B3	+	–	–	–	–

An analysis of interactive tables is presented in the form of recording highly correlated strengths and capabilities:

- B1B2C1C3

Table 4 - Interactive matrix of the project

Weaknesses					
Project Features		S1	S2	S3	S4
	B1	+	–	–	–
	B2	–	–	+	–
	B3	–	–	–	0

An analysis of interactive tables is presented in the form of recording highly correlated strengths and capabilities:

- B2S3

Table 5 - Interactive matrix of the project

Project Strengths						
Project Threats		C1	C2	C3	C4	C5
	U1	–	–	+	–	–
	U2	–	–	–	–	–
	U3	+	–	+	–	–
	U4	+	–	+	–	+

An analysis of interactive tables is presented in the form of recording highly correlated strengths and capabilities:

- U1U3U4C1C3

Table 6 - Interactive project matrix

Weaknesses					
Project Threats		S1	S2	S3	S4
	U1	+	+	–	+
	U2	–	0	–	+
	U3	+	–	–	–
	U4	+	–	–	–

An analysis of interactive tables is presented in the form of recording highly correlated strengths and capabilities:

- U1S1S2S4
- U1U2S4

Table 7 - The resulting SWOT matrix. Having compiled and analyzed the interactive project matrices, we will compose the final matrix of the SWOT analysis (Table 2).

	Strengths of the research project: C1. Claimed technology efficiency. C2. High functional development power. C3. Software and hardware accuracy C4. Easy to learn software. C5 Qualified staff.	**Weaknesses of the research project:** S1. Lack of an engineering company capable of building turnkey production S2. The need for a number of components for the program S3. Long delivery of components S4. Uniformity of use of the program
Capabilities: B1. The emergence of additional demand for a new product B2. Reduction of customs duties on materials used in scientific research B3. Increase the cost of competitive development	• The emergence of demand and a reduction in customs duties will make development cheaper, which means that the functional capacity of the device can be improved at the same cost • The development implementation strategy, like any other, is cyclical in time and requires either an acute shortage or an acute need for use. To increase the number of sales and implementation, first you need demand, with which we understand that the growth of industrial development entails a number of diseases and disorders, including motor ones. Also, toughening for drivers and medical workers for health forces	• Reducing customs duties on components, will expand the choice of delivery method, which will reduce the time for their delivery • Given the territorial affiliation of the project and its further improvement, namely increasing mobility. We can confidently believe that with due attention the project is being implemented in the Russian army and medical institutions of the country. Which eliminates almost all problems points

	enterprises to use accurate methods for measuring tremor and accuracy of hand movements (for example, surgery). It is important to note that a good product does not need advertising, you just need to put it on the market. Competitors stimulate the development of the project. If initially the project does not have any benefit for society, then any advertising will not save him.	
Threats: U1. Lack of demand U2. Developed competition of production technologies U3. Introduction of additional state requirements for product certification U4. Untimely financial support of scientific research by the state.	• Lower production cost and cost-effectiveness of the technology will increase demand, as well as minimize losses when introducing additional requirements for certification and untimely financial provision • Development, constant supply of new ideas and improvements will reduce risks and consolidate local positions.	• Lack of an engineering company as the main problem of the project. A marketing campaign should solve this problem. The search for potential clients and their public recall in the space of state hospitals and private hospitals will create a favorable environment for organizing any level of production

Thanks to the SWOT analysis, we can conclude that the strength of the project is its simplicity and accuracy of the assessment, which will expand the range of capabilities, as well as reduce the impact of threats on the implementation of the project. But the uniformity of the program and an expensive set of components can greatly complicate the delivery to the market.

4.2 Research Planning

4.2.1 The structure of work within the framework of scientific research.

Planning a set of proposed works is carried out in the following order:

- determination of the structure of work within the framework of scientific research;
- identification of participants in each work;
- setting the duration of work;
- building a schedule for research.

For each type of planned work, an appropriate position of performers was established.

In this section, a list of stages and works within the framework of the scientific research was compiled, the distribution of performers by type of work was carried out (Table 8).

Table 8 - a list of stages, works and distribution of performers.

Main stages	№ job	Work Content	Position performer	Duration, working days	Start date/Date of completion
Research Direction	1	Research Direction	Supervisor Engineer	7	1.02.2020 – 7.02.2020
	2	Drafting and approval of technical specifications	Supervisor	7	1.02.2020-7.02.2020
	3	Work scheduling by date	Supervisor	3	8.02.2020-10.02.2020
	4	Selection and study of materials on the topic	Engineer	5	10.02.2020-15.02.2020
Theoretical and experimental research	5	Writing a theoretical part	Engineer	6	15.02.2020-20.02.2020
	6	Evaluating the effectiveness of the results and determining the appropriateness of development work	Supervisor	3	20.02.2020-22.02.2020
	7	Component Check	Engineer	2	24.02.2020-25.02.2020
Development work					
Development of technical documentation and design	8	Development of a program algorithm in C#	Engineer	22	25.02.2020-20.03.2020
	9	Scene implementation in Unity3D	Supervisor Engineer	16	21.03.2020-9.04.2020
Production and testing of the layout (prototype)	10	Checking the interaction of all components	Supervisor Engineer	15	9.04.2020-25.04.2020
	11	Lab testing layout	Supervisor Engineer	10	25.04.2020-6.05.2020
	12	Evaluation of the results	Supervisor	16	6.05.2020-23.05.2020

Total duration of working time – 112 days

A Gantt chart, or harmonogram, is a type of bar chart that illustrates a project schedule. This chart lists the tasks to be performed on the vertical axis, and time intervals on the horizontal axis. The width of the horizontal bars in the graph shows the duration of each activity.

Table 9. A Gantt chart

№	Activities	Participants	T_c, days	Duration of the project											
				February			March			April			May		
				1	2	3	1	2	3	1	2	3	1	2	3
1	Research Direction	Skopchenko E.M Tolmachev I.V	7												
2	Drafting and approval of technical specifications	Tolmachev I.V	7												
3	Work scheduling by date	Tolmachev I.V	3												
4	Selection and study of materials on the topic	Skopchenko E.M	5												
5	Writing a theoretical part	Skopchenko E.M	6												
6	Evaluating the effectiveness of the results and determining the appropriateness	Tolmachev I.V	3												

	of development work													
7	Component Check	Skopchenko E.M	2											
8	Development of a program algorithm in C#	Skopchenko E.M	22											
9	Scene implementation in Unity3D	Skopchenko E.M Tolmachev I.V	16											
10	Checking the interaction of all components	Skopchenko E.M Tolmachev I.V	15											
11	Lab testing layout	Skopchenko E.M Tolmachev I.V	10											
12	Evaluation of the results	Tolmachev I.V	16											

Skopchenko E.M - Tolmachev I.V -

4.2.2 Research and Development Budget.

The costs required for the implementation of the project include:

- Material costs;
- Costs of special equipment for scientific research;
- The basic salary of the performers of the topic;
- Additional salary performers topics;
- Contributions to extra-budgetary funds (insurance contributions);
- Overhead.

4.2.2.1 Calculation of material costs.

Table 10 - Material costs.

Name	Unit of measurement	Amount		Price per unit., ruble.		Material costs (C_m), ruble.	
		HP	N	HP	N	HP	N
Ballpoint pen	Ruble.	1	1	15	15	15	15
Paper Packaging (A4)	Ruble.	0,5	0,5	350	350	175	175
Total:				365	365	190	190

Total item “material costs” - 380 rubles.

4.2.2.2 Calculation of costs for special equipment for scientific research.

The cost of special equipment includes all costs associated with the acquisition of programmers, microcontrollers and other peripherals. The cost of special equipment is determined according to the current price lists (Table 11).

Table 11 - Calculation of the budget costs for the purchase of special equipment for scientific work

№	Name of equipment	Number of pieces of equipment	Unit price, rubles.	The total cost of equipment, rubles
1.	USB wire	1	150	150
2.	Leap Motion Controller	1	12150	12150
3.	Epson Moverio BT-350	1	117000	117000
Total:				129300

Total under the item “costs for special equipment” - 129300 rubles.

4.2.2.3 Electricity costs.

On average, a personal computer runs for about 6 hours. As practice shows, the actual consumption of electricity by the average system unit, regardless of the values on the power supply (even 1000 watts), varies from 100 to 180 $Wh \cdot$ h in normal use (Internet surfing and other simple computer processes) , and up to 350 $Wh \cdot$ h with a significant load on the machine (this is work in resource-intensive programs, connecting additional equipment).

Therefore, taking into account the fact that the load on the PC reached low to high, the average value of electricity consumption will be (100 $Wh \cdot$ h + 180 $Wh \cdot$ h + 350 $Wh \cdot$ h) / 3 = 210 $Wh \cdot$ h. The approximate cost of electricity for a monitor is up to 40 $Wh \cdot$ h. The result is: 210 $Wh \cdot$ h + 40 $Wh \cdot$ h = 250 $wh \cdot$ h.

Multiplying the obtained value by 6 hours and adding the cost of electricity to the computer in the off state, the remaining 19 hours - about 4 W x 18 h = 72 W,

we find the required amount of PC electricity consumed per day - 6 h x 250 $Wh \cdot$ h + 72 W = 1,572 kW, which is 47,16 kW per month.

The tariff in the Tomsk region is 2.39 rubles / kWh.

Accordingly $\frac{2{,}39 \text{ rubles}}{0{,}46 \text{ kW}} = 5{,}19\ rub\ in\ h$, when the computer is on

Payment the total period of work for electricity will be $5{,}19\ rub * 6h *$ 112 days $= 3487{,}6$ rub

4.2.2.4 The main salary of performers.

The article includes the basic salary of employees directly involved in the implementation of the Scientific and Technical Task (including bonuses, surcharges) and additional salary:

$$S_{\text{sl}} = S_{\text{main}} + S_{\text{ov}},$$

Where S_{main} – basic salary;

S_{ov} – additional salary (12–20 % from S_{main}).

According to TPU data, the salary for an assistant professor of a department with a PhD degree is 35120 rubles without a regional coefficient. (DC = 1.3)

The main salary (S_{main}) of the head of the company is calculated according to the following formula:

$$S_{\text{main}} = S_d \cdot \text{T}_\text{p},$$

Where S_{main} – basic salary per employee;

T_p – the duration of the work performed by the scientific and technical worker, days;

S_d – average daily salary of an employee, rubles;

The average daily wage is calculated by the formula:

$$S_d = \frac{C_m \cdot \text{M}}{F_d},$$

Where C_m – monthly salary of an employee, rub.;

M – number of months of non-vacation work during the year:

when you leave at 24 work day M = 11.2 months, 5-day week;

when leaving at 48 workers days M = 10.4 months, 6-day week;

F_d – actual annual fund of working hours of scientific and technical personnel, workers days.

Table 12 - the balance of the working day

Working hours	**Supervisor**	**Engineer**
Calendar number of days	365	365
The number of days off – weekend – holidays	 52 13	 52 13
Loss of working time – Vacation – absenteeism	 48 10	 48 10
Valid annual work time fund	242	242

Monthly employee salary:

$$S_{\text{main}} = S_{\text{тс}} \cdot \left(1 + k_{\text{p}} + k_d\right) \cdot k_{\text{tp}},$$

Where S_{tr} - salary at the tariff rate, rubles.;

k_p – premium coefficient of 0.3 (i.e. 30% of S_{tr});

k_d – the coefficient of surcharges and allowances is approximately 0,2 – 0,5;

k_{tp} – regional coefficient equal to 1.3 (for Tomsk).

Table 13 - Calculation of basic wages

Performers	Category	$k_т$	S_{tr}, rub.	k_p	k_d	k_{tp}	C_m, rub	S_d, rub.	$T_{p,}$ rub. Day.	$S_{main,}$ rub.
Supervisor	PhD	–	35120	0,3	0,2	1,3	68484	2943	77	226611
Engineer	–	1	17890	0,3	0,2	1,3	34885	1499	99	148401
Total S_{main}										375012

Total under the article “Basic salary”– 375012 rubles.

4.2.2.5 Additional salary.

The costs of the additional wages of the theme performers take into account the amount of additional payments provided for by the Labor Code of the Russian Federation for deviation from normal working conditions, as well as payments related to the provision of guarantees and compensations.

The calculation is carried out according to the following formula:

$$S_{\text{add}} = k_{\text{add}} \cdot S_{\text{main}},$$

Where k_{add} - the coefficient of additional wages (at the design stage is taken equal 0,12 – 0,15).

S_{add} (supervisor) = 27193,3 rubles.

S_{add} (engineer) = 17808,1 rubles.

Total item “additional wages" – 45001,4 rubles.

4.2.2.6 Deductions extrabudgetary funds.

This expense item reflects mandatory deductions according to the norms established by the legislation of the Russian Federation to the state social insurance (FSI), pension fund (PF) and medical insurance from the costs of employee wages.

The amount of contributions to extra-budgetary funds is determined on the basis of the following formula:

$$S_{\text{ex}} = k_{\text{ex}} \cdot (S_{\text{main}} + S_{\text{add}}),$$

Where k_{ex} – rate of deductions for payments to extrabudgetary funds (27,1).

Table 14 - Contributions to extrabudgetary funds.

Performer	**Basic salary, rub.**	**Additional salary, rub.**
Supervisor	226611	27193,3
Engineer	148401	17808,1
Coefficient deductions to extrabudgetary funds	k_{ex} = 0,271	
Total		
Supervisor	68781	
Engineer	45042,6	

Total for the article "Contributions to extrabudgetary funds" – 113823,6 rubles.

4.2.2.7 Overhead.

Overhead costs take into account other expenses of the organization that are not included in the previous items of expenditures: printing and photocopying of research materials, payment of communication services, electricity, postal and telegraph expenses, reproduction of materials, etc. Their value is determined by the following formula:

$$S_{\text{ov}} = (\text{sum of articles1} \div 6) \cdot k_{\text{ov}},$$

Where k_{ov} – overhead factor.

The value of the coefficient of overhead costs can be taken in the amount of 16%.

S_{ov} = 106720,74

Total item “Overhead costs” – 106720,74 rubles.

4.2.2.8 Budgeting a research project.

The calculated value of the research work is the basis for the formation of the project cost budget, which, when forming the contract with the customer, is protected by the scientific organization as the lower limit of the cost of developing scientific and technical products (Table 18).

Table 15 - Calculation of the cost budget of the scientific and technical assignment

Title of the article	Amount, rub.	Share of costs,%
1. Material costs of the scientific and technical assignment	380	0,05
2. The cost of special equipment for scientific (experimental) work	129300	16,71
3. Electricity costs	3487,6	0,45
4. The costs of the basic salary of performers	375012	48,47
5. The costs of additional wages performers topic	45001,4	5,82
6. Contributions to extrabudgetary funds	113823,6	14,71
7. Overhead	106720,74	13,79
8. The budget of the costs of the scientific and technical assignment	773725,34	100

4.2.3 Assessment of the effectiveness of scientific work.

The effectiveness of this development lies in the fact that there are almost few analogues of this application, and the effectiveness and interest in medicine is quite high.

Thus, the goal is achieved, the tasks are solved.

According to the analysis of the competitiveness of technical solutions, it is obvious that the development is more promising than the existing work and has prospects for further development.

A SWOT analysis allows you to draw conclusions about the project's strengths, ways to expand the range of capabilities, as well as narrow the range of threats and vice versa.

A list of stages was compiled and performers distributed. A research schedule was developed, which includes 12 stages of training, which took 77 days for the leader and 99 days for the engineer.

The budget for scientific and technical research was calculated, the total amount of expenses amounted to 773725,34 rubles.

5. Social responsibility

Introduction

In this work, we developed a software package for the rehabilitation and assessment of motor disorders of the central nervous system in augmented reality. The work was carried out in the laboratory of the Department of Biomedical Cybernetics of the Biomedical Faculty of Siberian State Medical University. This laboratory is equipped with tools that allow you to study finger movements for assessing motor impairment “Leep Motion” and glasses “Epson Moveiro BT-300” as well as personal computers for managing, processing information and rehabilitating patients. To ensure the safety of workers and the environment, it is necessary to develop a set of technical and organizational measures that minimize the negative consequences of system design actions.

The purpose of this section is to analyze and evaluate harmful and hazardous labor factors that may affect project development personnel. Development of protective measures against these factors, assessment of working conditions. This section also discusses issues related to safety, fire protection and environmental protection, recommendations for creating optimal working conditions.

The potential risk is the use of equipment based on energy consumption GOST 12.1.030-81

When working with equipment should be guided by the following document: GOST R 12.1.019-2009

Collective protective equipment includes the use of a special research room. Personal protective equipment includes: when working with the equipment, hands should be clean and dry, the room temperature must correspond to the data specified in table №3, in order to avoid high or too low humidity of the room. At the end of the work, it is necessary to turn off all equipment and check the room in order to avoid dangerous situations.

5.1 Legal and organizational safety issues

5.1.1 Special legal norms of labor legislation

Most of the work that is carried out in production is directly related to the presence of dangerous and harmful production factors.

When hiring, the applicant is informed about this, and also indicated in the employment contract. And, accordingly, the employer is also obliged to familiarize not only with such working conditions, but also to teach safety measures, safe work practices, conduct internships at the workplace, provide training on labor protection, and periodically check the employee's knowledge of labor protection requirements.

In accordance with Art. 221 - 225 of the Labor Code of the Russian Federation in the conditions of dangerous and (or) harmful production factors, it should be provided by the employer of workers with personal protective equipment, special clothing, disinfecting or rinsing agents, all necessary share of first aid, etc. Also, at his own expense, the employer must ensure the issuance of special shoes and clothes, as well as other personal protective equipment. In addition, according to part 3 of article 221 of the Labor Code of the Russian Federation, the employer must provide care for special clothing (i.e. storage, repair, replacement, washing, drying).

It is also envisaged to undergo a medical examination for workers who perform work in conditions with dangerous and (or) harmful production factors, which is indicated in Article 213 of the Labor Code of the Russian Federation. Moreover, both during employment and in the process of work. In the order of the Ministry of Health and Social Development of the Russian Federation dated 12.04.2011 № 302n. The procedure for conducting a medical examination is indicated. The requirements of this document stipulate that a medical examination should be carried out once a year, or twice a year. It depends on the type of activity of the employee in the workplace, as well as on the presence of specific harmful factors.

According to part 6 of article 213 of the Labor Code of the Russian Federation, for workers whose work is associated with sources of increased danger

(for example, the influence of adverse production factors and harmful substances), as well as for those working under conditions of increased danger, a mandatory psychiatric examination should be performed at least once every 5 years. According to the Decree of the Ministry of Labor of the Russian Federation and the Ministry of Education of the Russian Federation of 13.01.2003 No. 1/29 “On approving the procedure for training on labor protection and testing knowledge of labor protection requirements for employees of organizations”, a production worker must, in addition to a medical examination at least once every 3 years, pass his knowledge test occupational safety, as well as first aid training for injured people [8].

5.1.2 Organizational arrangements for the layout of the working area

5.1.2.1 Microclimate of the working room

During work in the laboratory, it is necessary to create favorable conditions for the microclimate of the workplace. Prolonged exposure of a person to adverse weather conditions can dramatically worsen his well-being, reduce labor productivity and lead to diseases. The microclimate is determined by combinations of temperature, humidity, air velocity and thermal radiation acting on the human body.

High air temperature contributes to rapid fatigue of the worker, and can lead to overheating of the body, cause a violation of thermoregulation, poor health, decreased attention, heat stroke, increased stress on the heart. Low air temperature can cause local or general hypothermia, cause colds, and lead to diseases of the peripheral nervous system (radiculitis, bronchitis, rheumatism). Low humidity can cause the mucous membranes of the respiratory tract to dry out. Air mobility effectively contributes to the heat transfer of the human body and is positively manifested at high temperatures and negatively at low.

According to SanPin 2.2.4.548–96, work in the laboratory belongs to category 1b in terms of energy consumption - this is light physical work, which does not require lifting and carrying heavy loads, is performed while sitting or is connected with walking.

We give the optimal and permissible microclimate indicators of industrial premises in accordance with SanPin 2.2.4.548–96.

Table 16 - Optimum microclimate indicators

Period of the year	Temperature, degrees, ° C	Relative humidity, %	Air speed, m / s
Cold	21–23	40–60	0.1
Warm	22–24	40–60	0.1

Table 17 - Permissible indicators microclimate

Period of the year	Temperature, degrees, ° C		Surface temperature, ° C	Relative humidity, %	Air speed, m / s	
	Range below r.h.	Range above r.h.			for air temperature range below (relative humidity), no more	for air temperature range above (relative humidity), no more
Cold	19.0 – 20.9	23.1 – 24.0	18.0 – 25.0	15 - 75	0.1	0.2
Warm	20.0 – 21.9	24.1 – 28.0	19.0 – 29.0	15 - 75	0.1	0.3

Laboratory and housing water heating using radiators.

The measured microclimate indicators of the laboratory correspond to acceptable indicators: air temperature and surface temperature are 20℃ and 21℃ with a relative humidity of 50% in the cold season; 23℃ and 24℃ with a relative humidity of 55% in the warm season, which complies with SanPin N 2.2.4.548-96. [1,6].

5.1.2.2 Work area illumination

Not only eye health and human performance, but also his physical and psychoemotional state directly depends on the degree of illumination. Moreover, in premises for various purposes, the lighting requirements should vary. Also, when calculating the illumination, it is reasonable to take into account the characteristics of the working process carried out by a person in such a room, its frequency and duration.

In practice, two types of lighting are used: natural and artificial. Natural lateral and artificial working, as well as combined, which consists of local lighting of workplaces and general lighting of the room. These types of lighting are standardized by Set of rules 52.13330.2011.

In this laboratory, work is carried out on personal computers. According to SanPin 2.2.2 / 2.4.1340–03 "Hygienic requirements for personal electronic computers and organization of work", artificial lighting in premises for the operation of a personal computer should be carried out by a general uniform lighting system. Illumination on the table surface in the area of the working document should be 300 - 500 lux. Lighting should not create glare on the surface of the screen. Illumination of the screen surface should not be more than 300 lux.

In the laboratory, medium-precision work is carried out with the smallest size of the object of discrimination 0.5 - 1.0 mm, the contrast of the object of discrimination with the background is medium. The category of visual work is IV, subdischarge b, thus the illumination of the working surface from general lighting systems is 200 lux (Set of rules 52.13330.2011 "Natural and artificial lighting").

Table 18 - Lighting requirements for residential and public buildings.

Artificial lighting		Natural lighting, DLR,%, at	
Illumination on the working surface from the general lighting system, lux	Coefficient of pulsation of illumination CP,%, no more	Top lighting or combined	Side
300	20	2.5	0.7

Thus, there are no violations of the lighting standards in the laboratory [5].

5.1.2.3 Noise level at the workplace

Noise pollution of the environment at the workplace adversely affects workers: attention is reduced, energy consumption increases with the same physical activity, the speed of mental reactions slows down, etc. As a result, labor productivity and the quality of the work performed are reduced.

The main sources of noise in rooms equipped with computer technology are printers, plotters, copying equipment and equipment for air conditioning, fans of cooling systems.

n accordance with SanPin 2.2.2 / 2.4.1340–03 “Hygienic requirements for personal electronic computers and organization of work”, the noise level at workplaces should not exceed 50 dBA [6].

5.1.2.4 Elevated electromagnetic radiation

PCs are sources of broadband electromagnetic radiation:

- soft x-ray;
- ultraviolet 200-400 nm;
- visible 400–750 nm;
- near infrared 750–2000 nm;
- 3 kHz radio frequency range;
- electrostatic fields;

Table 19 - Temporary permissible levels of EMF created by PC in the workplace.

Name of parameters	Temporary Permissible Levels	
Electric field strength	In the frequency range 5 Hz - 2 kHz	25 V/m
	In the frequency range 2 kHz - 400 kHz	2.5 V/m
Magnetic flux density	In the frequency range 5 Hz - 2 kHz	250 nT
	In the frequency range 2 kHz - 400 kHz	25 nT
Electrostatic field strength		15 kV/m

If at the surveyed workplace equipped with a PC, the intensity of the electric and / or magnetic field in the range of 5 - 2000 Hz exceeds the values given above, it is necessary to measure the background EMF levels of industrial frequency (with the equipment turned off). The background level of the electric field with a frequency of 50 Hz should not exceed 500 V / m.

The background levels of the magnetic field induction should not exceed the values causing violations of the requirements for the visual parameters of the VDT. As a precaution, you should limit the duration of work with the PC, do not place them concentrated in the work area and turn them off if they are not working. Along with this, it is necessary to install air ionizers in the room, ventilate the room more often and, at least once during the work shift, clean the screen of dust (SanPin 2.2.2 / 2.4.1340–03) [2,3].

5.1.2.5 Arrangements for the layout of the working area

Of great importance in the work is the organization of jobs for employees and the creation of favorable working conditions. Work in the laboratory is usually characterized by low motor activity, monotony, prolonged stay indoors. All this causes fatigue and naturally affects the results of labor.

In a laboratory with an area of 30 m^2, no more than 5 people can work simultaneously, therefore, the norms of the office space are taken into account. To ensure favorable microclimate conditions, the room is equipped with a hood. The depth of the table is 800mm, width 1.5m. The distance between workers is at least 1.5 m. The width of the passage is about 2m. The planes of computer screens are perpendicular to the windows, the dimensions of the furniture correspond to the size of the room, there is no clutter.

The mode of work and rest provides for compliance with a certain duration of continuous work on the PC and breaks, regulated taking into account the duration of the shift, types and categories of work [7.8].

Labor in the laboratory belongs to category B - creative work in dialogue with a PC, the third category of severity. The mode of work and rest of operators working with computers should be as follows: after every hour of intensive work, a

15-minute break should be arranged, with a less intensive break every 2 - hours. The effectiveness of regulated breaks increases when combined with workout gymnastics. Gymnastics should include a set of exercises aimed at filling the deficit of motor activity, relieving tension in the muscles of the neck, back, and reducing vision fatigue. It is carried out for 5 to 7 minutes. 1-2 times per shift (SanPin 2.2.2 /2.4.1340–03)

Since the work was carried out mainly on a PC, according to (SanPin 2.2.2 /2.4.1340–03) the following requirements are imposed on the layout of the workplace of a computer operator:

- The desktop should be adjustable in height within 680-800 mm; in the absence of such a possibility, its height shall be 725 mm. The optimal dimensions of the worktop are 1400x1000 mm. Under the tabletop, there should be free legroom with a height of at least 600 mm, a width of 500 mm, and a depth of 650 mm. On the surface of the desktop for documents, it is necessary to provide for the placement of a special stand, the distance from which should be the same as the distance from the eyes to the keyboard, which reduces visual fatigue.
- The working chair (chair) must be equipped with a lifting and swiveling device that provides seat and backrest height adjustment; its design should also include a change in the angle of inclination of the back. The working chair must have armrests. The adjustment of each parameter should be easy to carry out, be independent and have a secure fit. The height of the seat surface must be adjustable between 400–500 mm. The width and depth of the seat must be at least 400 mm. The height of the back surface should be at least 300 mm, width at least 380 mm. The radius of its curvature in the horizontal plane is 400 mm. The angle of the backrest should vary between 90-110º to the plane of the seat. The coating material of the working chair should allow easy cleaning from contamination. The surface of the seat and back should be semi-soft, with a non-slip, non-electrifying and breathable coating.

5.2 Industrial safety

Industrial safety is understood as a system of organizational measures and technical means that prevent or reduce the likelihood of exposure to working personnel of dangerous traumatic production factors that arise in the work area during the course of labor activity. In our work, it is necessary to find out dangerous and harmful factors that may arise when working with an information system. Subsequent selection is made using GOST 12.0.003–2015 "Dangerous and harmful production factors. Classification". The selection results are shown in the table below.

Table 20 - Harmful and dangerous factors when working with a computer.

Source of factor, name of the type of work	List of factors (according to GOST12.0.003–2015)		Relevant regulatory documents
	Harmful	Dangerous	
1) Computer work	1) The microclimate of the working room; 2) increased or decreased humidity of the air of the working area 3) Illumination of the working area; 4) Increased noise in the workplace; 5) Increased level of electromagnetic radiation	1) Exposure to electrical current	1) SanPin 2.2.4.548–96; 2)GOST R 12.1.019–2009; 3)GOST 12.1.030–81; 4)SP 52.13330.2011; 5)SanPin 2.2.2/2.4.1340–03; 6) GOST 12.1.003–83; 7) SanPin 2.2.2/2.4.1340–03

5.2.1 Analysis of harmful and dangerous factors that can be created by object of study and laboratory during research

5.2.1.1 Analysis of identified hazardous factors

The laboratory room where the work was carried out belongs to category B [4].

The causes of the fire may be:

1. Short circuit currents.
2. Malfunction of electric networks.
3. Ignorance of fire safety rules or negligence of staff.
4. Smoking in the wrong places.

In this regard, the following fire safety standards must be observed in the laboratory:

1. To protect the network from overloads, it is forbidden to include additional non-intended consumers.
2. Carry out work in the laboratory only when the equipment and electrical wiring are in good condition.
3. For extinguish a fire (fire extinguisher).
4. Have a plan of evacuation of people, which should hang in a conspicuous place.
5. Place the equipment so that there is sufficient passageway to the exit.

The building of the Siberian State Medical University, in which the laboratory is located, meets the fire safety requirements.

5.2.1.2 Electrical safety

Electrical safety is a system of organizational and technical measures aimed at protecting people from the harmful and dangerous effects of electric current.

There is a danger of electric shock in all cases where electrical installations and equipment are used. Electrical installations are classified by voltage - with a rated voltage of up to 1000 V (rooms without increased danger), up to 1000 V with the presence of an aggressive environment (rooms with increased danger) and over

1000 V (rooms especially dangerous) (according to the Rules for the Installation of Electrical Installations).

To ensure safe operation, it is necessary to exclude possible sources of electric shock:

1. Accidental contact with live parts under voltage.
2. The appearance of voltage on the mechanical parts of electrical equipment (cases, covers, etc.) due to insulation damage or other reasons.
3. The occurrence of stress on the ground or supporting surface.

According to the degree of danger of electric shock, this laboratory belongs to rooms without increased danger, it is a dry room without increased dusting, the air temperature is normal, the floor is covered with insulating material. All electrical equipment and devices are in place and have protective grounding with a resistance of not more than 4 ohms (GOST 12.1.030-81.) All employees undergo initial electrical safety training.

Before starting work, it is necessary to check the serviceability of conductive wires. It is forbidden to use wires with damaged insulation or without insulation, as well as wires that are not equipped with plugs or soldered terminals, to connect electrical appliances.

Instruments must be kept clean. At the end of the work, disconnect the equipment from the network.

Electric shock during GQW can occur during careless handling of the connecting wires or in the event of an emergency - shorting of live parts to the equipment case in the absence of grounding and grounding. This can happen when working with electrical laboratory equipment [2].

Table 21 - Permissible levels of touch voltages and currents.

Mode	Type Of Current					
	Variable, 50 Hz			Constant		
	U, B	I, мА	Duration, min	U, B	I, мА	Duration, min
Normal	2	0.3	<10	8	1	<10

First aid to the victim should consist in immediately disconnecting the current that caused the injury, disconnecting (in rubber gloves) the victim from the leads and calling the doctor. If the victim is conscious, but before that he was swooning or has been under current for a long time, he needs to ensure peace before the doctor arrives. If the victim lost consciousness, but breathing persists, it is necessary to put him in comfortably, evenly, unfasten his tight clothes, create an influx of fresh air, remove unnecessary people from the room, breathe ammonia, spray with water, rub and warm the body. With convulsive and rare breathing, artificial respiration is necessary. In the absence of signs of life (lack of pulse and breathing), the victim cannot be considered dead. It is necessary immediately, without wasting time, before the arrival of the doctor to do artificial respiration.

5.2.2 Determination of air exchange in laboratory

Air exchange in public buildings is necessary to clean the air of harmful substances: to remove harmful substances (emitted harmful gases, vapors and dust), to remove water vapor and excess heat.

In residential and public buildings, carbon dioxide (CO_2) exhaled by people is a constant harmful emission. The required air exchange is determined by the amount of carbon dioxide exhaled by a person and by its permissible concentration. The amount of carbon dioxide, depending on the age of the person and the work performed, as well as the permissible concentration of carbon dioxide for different rooms. The carbon dioxide content in the air can be determined by the chemical composition of the air. However, given the increased

carbon dioxide content in the atmosphere of settlements, the CO_2 content should be taken into account when calculating:

- for large cities (over 300 thousand inhabitants)– 0.5 l/m^3.

Determine the required rate of air exchange in a laboratory for two people, if the volume of the room is V=68 m3. The laboratory is located in 603 office of the laboratory building SibSMU. The amount of carbon dioxide exhaled by an adult with light work in an institution is 18 l/h [12]. The maximum permissible concentration of carbon dioxide for institutions is 1.25 l/m3 [12]. The required air exchange in the laboratory is determined by the formula 1:

$$L = \frac{G*P}{x_v - x_n} \quad (13)$$

where L – air exchange required, m^3/h;

G – the amount of harmful substances released into the room air, g/h;

P – number of people working in the laboratory;

x_v – maximum permissible concentration of harmfulness in the air of the working area of the room [9], mg/m^3;

x_n – the maximum possible concentration of the same harmfulness in the air of populated areas [10], mg/m^3.

The rate of air exchange (n), which shows how many times in one hour the air is completely replaced in the room, which is determined by the formula 2.

$$n = \frac{L}{V_n}, h^{-1} \quad (2)$$

where V_n is the internal volume of the room, m^3

According to [11], the permissible air exchange rate should be in the range from 3 to 10 h^{-1}.

Required air exchange in the laboratory, according to 1:

$$L = \frac{18 * 2}{1.25 - 0.5} = 48 \frac{m^3}{h}$$

The required air exchange rate is:

$$n = \frac{48}{68} = 0.7\ h^{-1}$$

Thus, the calculated consumed air exchange in the laboratory should be 48 m^3/h.

5.3 Ecological safety

Now it is necessary to consider in this subsection the nature of the environmental impact of the proposed solution. Wastes are substances or mixtures of substances that are deemed unsuitable for further use within the framework of the technologies that are available, or after the domestic use of this product. Industrial waste is solid, gaseous and liquid production waste that is obtained as a result of thermal, chemical, mechanical or other transformations of materials of anthropogenic and natural origin. Household waste is solid waste that is generated as a result of human household activities.

The devices used in this work do not emit hazardous and harmful substances into water and air, since only the computer and various peripheral devices connected to it are actually used. Therefore, we can conclude that when using devices harm to the hydrosphere and the atmosphere is not inflicted.

In case of equipment malfunction, it must be disposed of. The disposal procedure implies that the equipment will first be decommissioned; then, in order to confirm the presence of equipment malfunction, it will be tested by specialists who will disassemble the device. Next is the processing of materials (plastic, various metals). Recycling is an activity that involves the management of waste for the safe disposal of waste or to ensure reuse [6].

5.4 Safety in emergency situations

In case of emergency, you must immediately call the fire department at number “01” from your business phone or “101” from your mobile phone.

The notification of civil defense alerts in the event of an emergency to the personnel of the objects is carried out using voice information through broadcasting channels, radio broadcast networks and communication networks. On the territory of the Siberian State Medical University they do not use, do not produce, do not process, do not store radioactive, fire hazardous, and also explosive substances that create a real threat of an emergency source. As the most probable technological emergencies, the project considers:

1. Fire at the territory object.

Fire hazards for humans include toxic combustion products, low oxygen concentration, open flames, smoke, and high air temperatures.

The following measures must be observed to prevent fire:

1. Reducing the determining size of the combustible medium.
2. Prevention of the formation of a combustible medium.

In case of overheating, short circuits, etc. possible ignition of electrical installations, wiring. To extinguish the fire, it is necessary to use special means, it is impossible to use water and other conductive substances. Therefore, the premises should be equipped with means for extinguishing electrical installations and electrical wiring under voltage.

Conclusion

The laboratory is located in Tomsk with a continental cyclonic climate. Natural phenomena such as earthquakes, floods, droughts, hurricanes in this city are absent, but there is a likelihood of such an emergency of a natural nature, as severe frosts. Achieving critically low temperatures will lead to accidents in heating and life support systems, suspension of work, frostbite, and even casualties among the

population. In the event of pipe freezing, spare heaters must be provided. Their quantity and capacity should be sufficient so that work in production does not stop. In the event of a power outage or accident in the mains, it is necessary to use a diesel generator for emergency lighting in the building.

Such items as industrial and environmental safety were examined, various harmful and dangerous factors and methods of dealing with them were identified, a list of measures to reduce the threat from the possibility of emergency situations was identified, legal and organizational safety issues were studied, and organizational measures were determined during the layout working area.

Conclusion

In this final qualifying work, a software package for rehabilitation working in augmented reality was developed and put into practice. The program algorithm is written in C #. Scenes are made in Unity, the connection between scenes is also carried out in Unity using scripts. The program is visual and very easy to learn. In the future, it is planned to improve the design by reducing the size and increasing the mobility of the entire installation. As a result, we can say that the goal of the final qualification work was fully achieved.

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Appendix A

(Required)

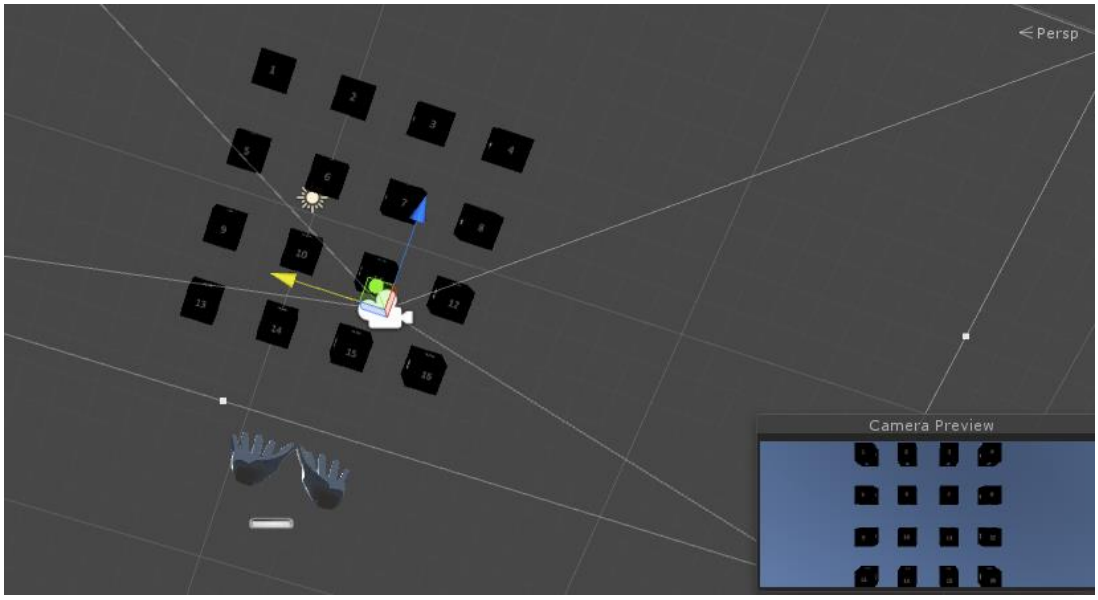

Figure A.1 Base scene.

Appendix B

(Required)

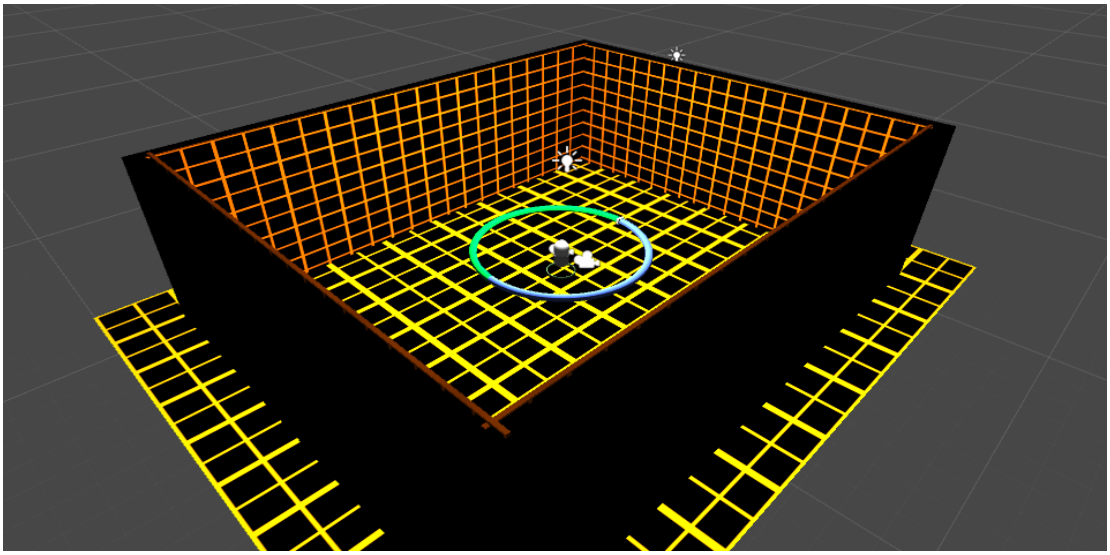

Figure B.1 Room scene.

Appendix C

(Required)

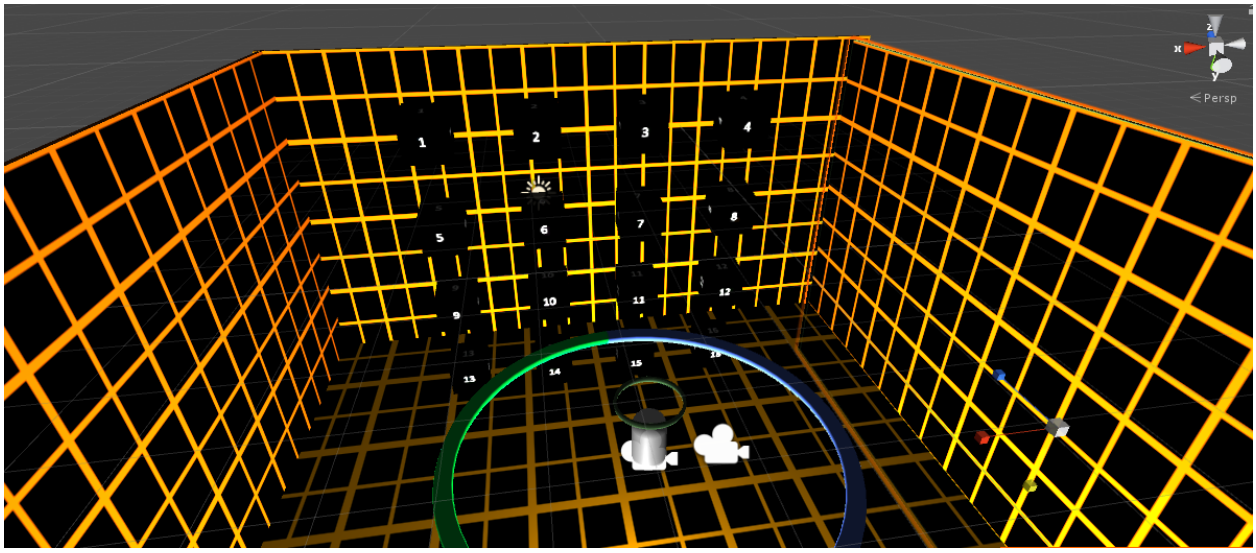

Figure C.1 United scene.

Appendix D

(Required)

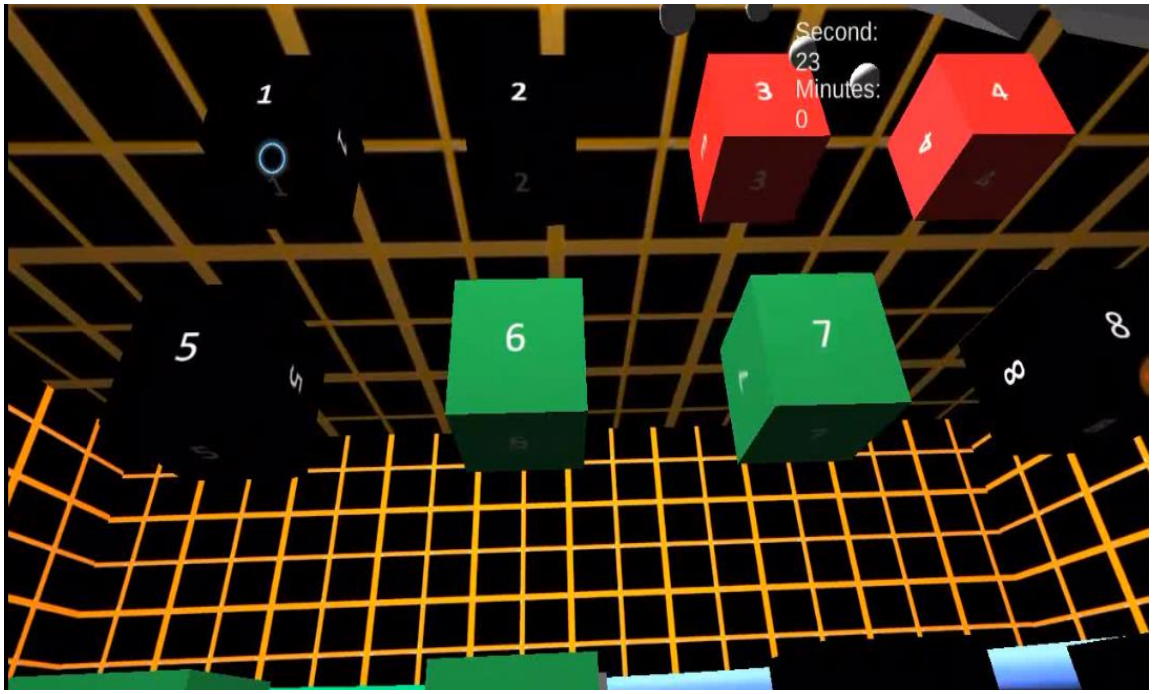

Figure D.1. Application for augmented reality glasses, inside view.

Appendix E

(Required)

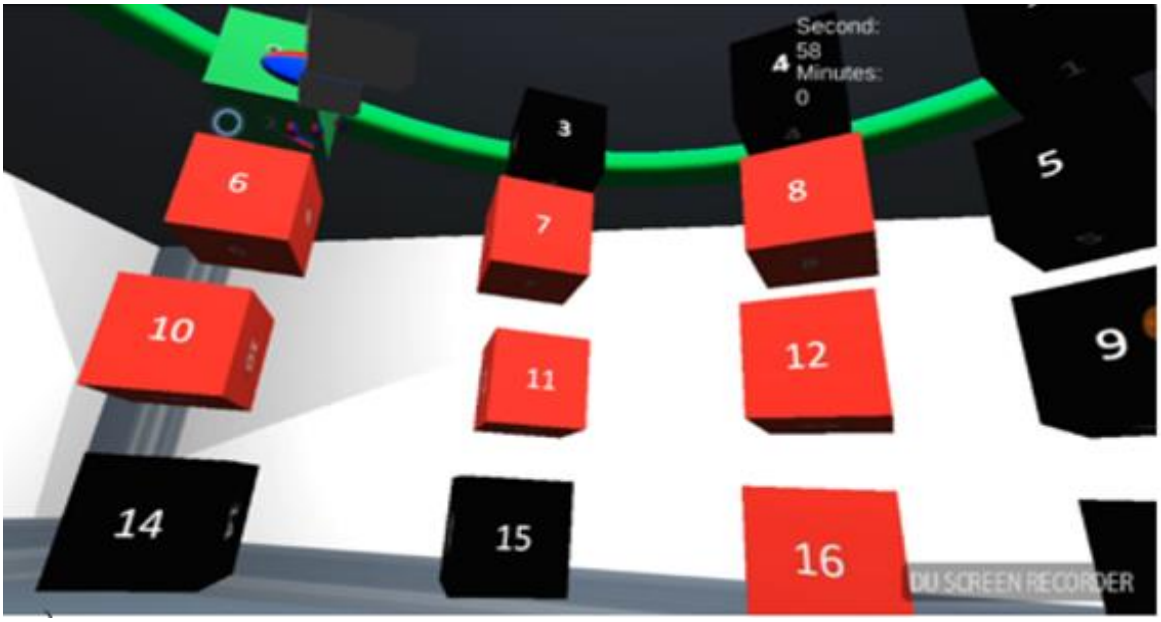

Figure E.1 Application for augmented reality glasses, inside view (accuracy).

Appendix F

(Required)

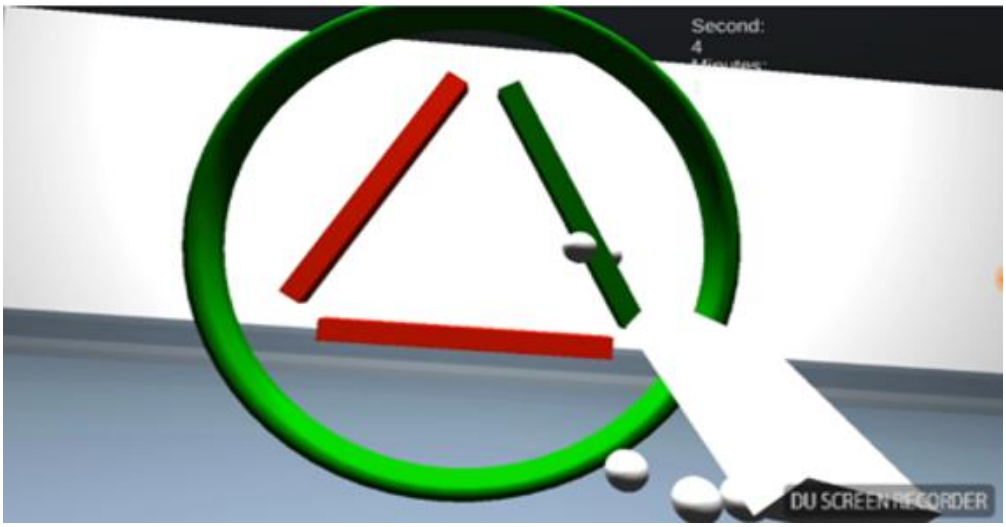

Figure F.1 The second type of work is based on the "static movement of the hand".

Appendix G

(Required)

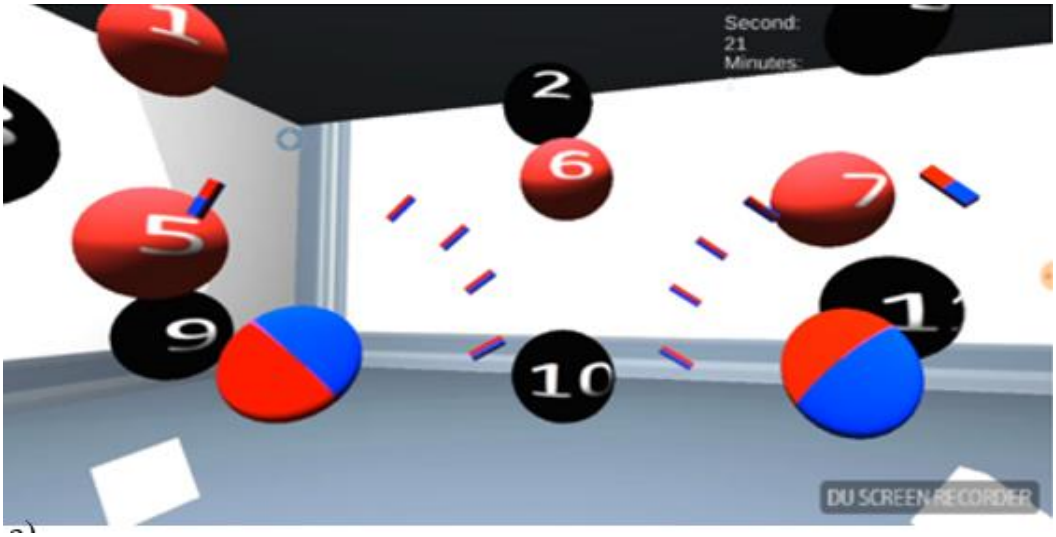

Figure G.1 The third type is the movement of the brush based on the “statodynamics”.

Appendix H

(Required)

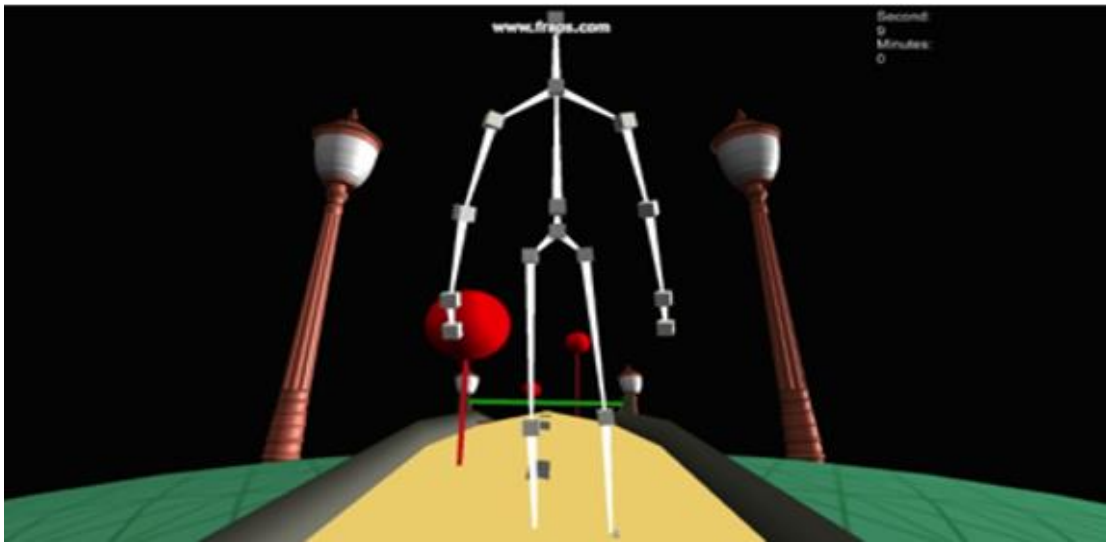

Figure H.1 The last type of task is based on balance passing obstacles.